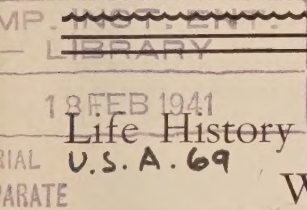


Circular No. 572

October 1940 • Washington, D.C.

UNITED STATES DEPARTMENT OF AGRICULTURE



Life History and Control of the Imported Willow Leaf Beetle

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INTRODUCTION

The imported willow leaf beetle (*Plagioder a versicolora* (Laich.)) is a small metallic-blue beetle, resembling certain of the well-known flea beetles. It is a European species and was described by Von Laicharting in 1781.² It is not known just when it was introduced into this country, but in 1915 it was recorded as having been present in Staten Island, N. Y., in 1911.³ During the past few years it has become very prevalent in many sections of New England. It has also been reported as abundant in New York, New Jersey, Pennsylvania, Maryland, and Delaware.

NATURE OF INJURY

The imported willow leaf beetle, so far as observed in New England, confines its feeding to willows, although it has been recorded as feeding on poplar.⁴ It prefers the black willow (*Salix nigra* Marshall) and

¹Now in the Division of Gypsy and Brown-tail Moth Control.

The writer is indebted to C. W. Collins, who was in charge of the Bureau of Entomology and Plant Quarantine laboratory formerly located at Melrose Highlands, Mass., and under whose direction the work was conducted, and to C. M. Symonds and H. A. Bess for assistance in conducting the experiments.

²LAICHTARTING, JOHANN N. VON. VERZEICHNIS UND BESCHREIBUNG DER TYROLES INSECTEN. 2 v. Zurich. 1781-84. See v. 1, p. 148.

³SCHAEFFER, CHARLES. NEW COLEOPTERA AND MISCELLANEOUS NOTES. III. N. Y. Ent. Soc. Jour. 23: 235-238. 1915.

⁴FELT, EPHRAIM PORTER, and RANKIN, HOWARD W. INSECTS AND DISEASES OF ORNAMENTAL TREES AND SHRUBS. 507 pp., illus. New York. 1932.

WEISS, HARRY B., and DICKERSON, EDGAR L. PLAGIODERA VERSICOLORA LAICH.—an imported poplar and willow pest. Canad. Ent. 49: 104-109, illus. 1917.

WEISS, HARRY B. THE MORE IMPORTANT NURSERY INSECTS IN NEW JERSEY. N. J. Dept. Agr. Cir. 26, 46 pp., illus. 1919.

the golden willow (*Salix alba* var. *vitellina* (L.) Koch), but also feeds on the Babylon weeping willow (*Salix babylonica* L.) and the shiny willow (*Salix lucida* Muehlenburg). The adults sometimes feed entirely through the leaf; usually, however, they attack the surface, leaving a network of veins plainly visible. They do not confine their attack to one particular spot, but move from leaf to leaf. The larvae feed on both surfaces of the foliage, but more often on the lower surface. Considerable feeding has been observed on the shiny willow, but on this tree the feeding was only on the under surface of the leaves. The larvae skeletonize the foliage, and are usually found in groups or rows (fig. 1) moving across the surface of the leaf as they feed. The

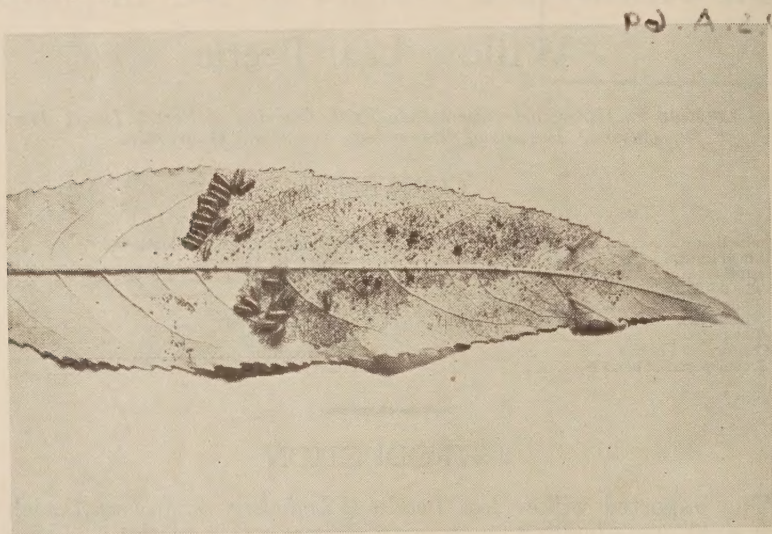


FIGURE 1.—Larvae of the imported willow leaf beetle feeding on a willow leaf.

foliage turns brown after heavy feeding by the larvae, and in heavy infestations trees have been noted to be entirely brown by the middle or latter part of June.

DESCRIPTIONS

THE ADULT

The adult is a small, robust beetle, oval in outline, averaging about 3.9 mm. in length by 2.8 mm. in width. It is metallic blue, sometimes tinged with red or bronze.

THE EGG

The egg is pale yellow, about 1.7 mm. long and 0.7 mm. wide, slightly larger at the base, or attached end, than at the apex. The eggs are deposited on end in irregular masses containing from 2 to about 30, but usually between 8 and 15. They are placed on either surface of the leaf, although the majority are placed on the lower surface.

THE LARVA

FIRST INSTAR

The newly hatched larva (fig. 2, *A*) is about 1.8 mm. in length and 0.7 mm. in width, of a light cream color with somewhat regular rows of protuberances running both longitudinally and transversely. A large protuberance is located on each dorsolateral margin of both the

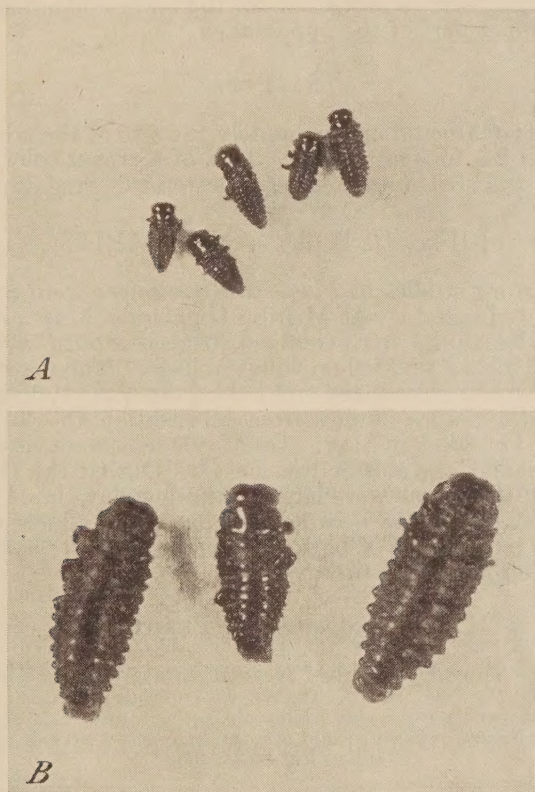


FIGURE 2.—Larvae of the imported willow leaf beetle: *A*, Newly hatched larvae, $\times 7$; *B*, full-grown larvae, $\times 6$.

mesothorax and the metathorax, and a smaller one on the dorsolateral margin of each segment of the abdomen. A short bristle is located at the center of each protuberance. The larva darkens shortly after it has emerged from the eggshell.

SECOND INSTAR

After the first molt the larva is about 2.2 mm. in length, and the protuberances are more pronounced, especially those on the dorsolateral margins, but in other respects it differs little from the first instar.

THIRD INSTAR

After the second molt the larva averages 3.2 mm. in length, the protuberances are much more pronounced, and the larva shortly becomes jet black. It grows rapidly during the third instar and when full-grown averages 4 to 5 mm. in length (fig. 2, *B*). It then attaches the posterior end firmly to the leaf and shortens and forms the prepupa. Shortly after this the outer skin breaks and is pushed down to where it forms a protection for the lower abdominal segments, leaving the upper part of the pupa naked.

THE PUPA

The pupa is ovate and approximately the size of the adult, 3.2 to 4 mm. long and 2.5 to 3 mm. wide. It is of a cream color with black markings, is rounded anteriorly and posteriorly, and tapers toward the apex.

LIFE HISTORY AND HABITS

The life-history studies of *Plagioder a versicolora* were conducted in a well-ventilated insectary at Melrose Highlands, Mass., during 1933 and 1934. The adults were confined in glass-topped wooden trays, 12 by 12 by 5 inches, and fed on willow foliage. The mated pairs and larvae were kept in glass vials, and fed on the same type of foliage.

In 1933 adults were issuing from hibernation the latter part of April and the first week in May. On May 9 they were very abundant, and an occasional egg cluster was noted. During the first week in June many of the larvae were large, and a few days later pupae were found. When the pupae became abundant and adults were beginning to issue, collections of both were made, and life-history studies were carried on from that time.

DEVELOPMENTAL PERIODS

The records shown in table 1 were obtained during the season of 1933.

TABLE 1.—Maximum, minimum, and average development periods of the imported willow leaf beetle, 1933

Period	Maximum	Minimum	Average
	Days	Days	Days
Incubation.....	6	3	4.3
Larval.....	19	11	14.8
Prepupa and pupal.....	11	2	4.9
Egg to adult.....	30	17	23.4

In 1934 the life-history studies were begun as soon as the adults issued from hibernation the first week in May and were continued throughout the season. As soon as the eggs hatched, each individual larva was placed in a glass tube, carefully fed, and its development noted each day. In this way the length of each instar, the prepupal and pupal stages, and the total time elapsed from egg to adult were

determined. A number of larvae of each generation were handled in this way, and the records shown in table 2 were obtained. The studies indicated that there were three generations of the beetle and a possible fourth generation each year in Massachusetts.

TABLE 2.—*Time spent by the various generations of the imported willow leaf beetle in the different stages at Melrose Highlands, Mass., in 1934*

Stage	Time spent in stage by generation indicated				Average
	First	Second	Third	Partial fourth	
	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>
Egg.....	10.0	5.0	3.0	3.0	5.25
Larval.....	13.6	8.8	10.5	15.6	12.12
Prepupal.....	1.1	1.1	1.2	1.7	1.27
Pupal.....	2.9	3.0	3.2	4.0	3.27
Total.....	27.6	17.9	17.9	24.3	21.91

LONGEVITY OF ADULTS

A large number of hibernating adults were collected on May 7, 1934. Of these, a number of mated pairs were placed in glass vials while the remainder were put in a large glass-topped tray and all were fed. The last adult in the vials died on August 10, and the last one in the tray died on August 4.

Of the first-generation beetles, which issued June 8 to 14 and were segregated the same way as the preceding lot, the last one in the vials died on September 4, and the last one in the tray died on October 11.

Of the second-generation beetles, similarly handled, which issued July 9 to 13, the last one in the vials died on September 12, and all were dead in the tray on October 15.

Various attempts were made to induce these beetles, especially the adults of the first and second generations, to become quiescent. Compartments containing debris were constructed inside the glass-topped trays for the beetles to enter, should they so desire, and at various times the adults were placed in the compartments containing the debris, but at no time could they be induced either to enter or to remain in them.

No difficulty was encountered with the third generation, however, since when they had fed sufficiently they voluntarily entered the compartments to hibernate.

EGG PRODUCTION

The egg-production records obtained are shown in table 3.

The largest number of eggs laid by one female was 357. It will be noted that the highest average in oviposition was made by the adults from hibernation; whereas, in each succeeding generation, the average number of eggs decreased. No attempt has been made to determine the reason for this, but the results were obtained through carefully conducted experiments in which the adults were given the best of care throughout the season. Under normal field conditions the average oviposition might be somewhat different from that obtained in the insectary.

SEASONAL HISTORY

The imported willow leaf beetle passes the winter in the adult stage under the bark of the willows (fig. 3), in debris at the base of the trees, and in tufts of grass and loose foliage around or near the trees. The overwintered beetles emerge from their hibernating quarters from the last week in April to the early part of May and, after a brief interval of feeding, mate and begin to deposit eggs for the first generation.

The eggs hatch in a few days and, following development of the larvae, the adults of the first generation appear the first part of June. After an interval of about 10 days eggs are deposited by the first-generation beetles and from these, through the normal stages, adults of the second generation develop during the first part of July. Likewise, the adults of the second generation feed, mate, and deposit eggs,

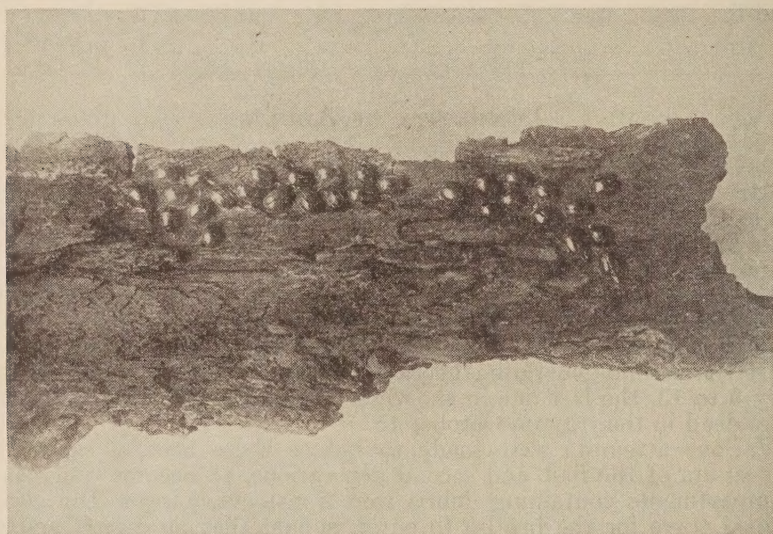


FIGURE 3.—Section of willow bark removed to show adult imported willow leaf beetles in hibernation. About natural size.

and from these the third generation develops, the adults appearing during the first and second weeks in August. These adults feed heavily for a number of days, and by the last of August practically all have entered hibernation. Only a very few of these adults mate and deposit eggs that develop to a partial fourth generation.

TABLE 3.—*Egg-production records obtained for females of the imported willow leaf beetle*

Kind of adult female	Individuals observed	Eggs laid (average)
	<i>Number</i>	<i>Number</i>
Hibernating	20	175
First generation	22	156
Second generation	22	38
Third generation	6	16

All stages of the insect can be found in the field during June, July, and part of August, owing to the fact that the generations overlap considerably.

The seasonal occurrence of the various stages of the insect for the different generations is given in table 4.

TABLE 4.—*Seasonal occurrence of the various stages of the imported willow leaf beetle at Melrose Highlands, Mass., in 1934*

Stage	Seasonal occurrence of generation indicated			
	First	Second	Third	Partial fourth
Adults in field	May 1 to 7.			
First eggs deposited	May 8.	June 19.	July 16.	Aug. 13.
First eggs hatched	May 18.	June 24.	July 19.	Aug. 16.
Prepupae	May 31 to June 6.	July 2 to 6.	July 20 to Aug. 4.	Aug. 29 to Sept. 4.
Pupae	June 2 to 7.	July 3 to 7.	July 30 to Aug. 5.	Sept. 2 to 5.
Adults	June 6 to 11.	July 6 to 10.	Aug. 2 to 9.	Sept. 5 to 16.

It will be noted from table 2 that the egg period of the first generation was much longer than that of the later generations. This was because of some cool days in the early part of May, which retarded the hatching considerably. The larval period in both the early and late part of the season was somewhat longer than was the case with the intervening generations. Cold or chilly periods retarded both hatching of the eggs and feeding by the larvae, and hence lengthened the period to maturity.

NATURAL CONTROL

WINTER MORTALITY

The imported willow leaf beetle hibernates as an adult subjected to varied weather conditions, and extremely cold winters are fatal to adults not well protected. The winter of 1933-34 was very severe in eastern Massachusetts, a temperature of -18° F. being recorded at Melrose Highlands, and the following spring no living adults were found in crevices or under any bark above the snow line.

INSECT ENEMIES

A number of pupae of *Plagiodera versicolora* in a collection made on June 22, 1933, at Milton, Mass., did not issue as adults, and it was found that they had been destroyed by a parasite, *Schizonotus sieboldi* (Ratz.).⁵ On August 3, 1933, larvae of *P. versicolora* were collected at Saugus, Mass., and fed until pupation, after which the pupae were placed in vials. Examination later showed that these were quite highly parasitized by *S. sieboldi*. Dowden⁶ has made a special study of the life history and habits of this parasite.

⁵ Determined by C. F. W. Muesebeck.

⁶ DOWDEN, PHILIP B. SCHIZONOTUS SIEBOLDI, AN IMPORTANT PARASITE OF THE IMPORTED WILLOW LEAF BEETLE (PLAGIODERA VERSICOLORA). Jour. Agr. Res. 58: 581-592, illus. 1939.

ARTIFICIAL CONTROL

Since this insect has three full generations and a partial fourth, it is obviously present in large numbers for an extended period during the summer. It is necessary, therefore, to give continuous protection to the trees for quite a while, for treated trees are often reinfested to a considerable extent from nearby untreated trees.

A number of control experiments were conducted during the two seasons with different strengths of lead arsenate sprays in combination with one-quarter of a pint of fish oil as an adhesive to each pound of the poison. In all the experiments the quantities of lead arsenate mentioned were used in 100 gallons of water.

On June 8, 1933, two groups of willows at Milton, Mass., were sprayed with lead arsenate at the rates of 3 and 5 pounds to 100 gallons of water, with fish oil as an adhesive. These trees were heavily infested, and many adults and larvae were noted on the foliage. On June 22, 1933, two other groups of heavily infested trees in Stoneham, Mass., were sprayed with lead arsenate mixtures of the same strengths as before. Care was taken to spray both the upper and lower surfaces of the foliage.

Observations were made on these trees during the summer, and the 5-pound dosage applied on June 8 seemed to show somewhat better results than the 3-pound mixture, whereas very little difference in efficiency was noted between the 3- and 5-pound dosages applied June 22. The only appreciable feeding noted during the season was on the new growth which came after the trees were treated. The check trees were heavily fed upon, the greater part of the foliage having turned brown and shriveled.

For the control experiments in 1934, a long row of large, medium to heavily infested willows located at Belmont, Mass., were selected. On May 28 and on June 22 a number of these trees were treated with lead arsenate mixtures. Table 5 gives the data relative to these experiments.

TABLE 5.—*Dosages of lead arsenate used, dates of applications, and numbers of trees sprayed for the control of the imported willow leaf beetle at Belmont, Mass., 1934*

Date of treatment	Lead arsenate used per 100 gallons	Fish oil used per 100 gallons	Trees treated (number)
	<i>Pounds</i>	<i>Pints</i>	
May 28.....	3	$\frac{3}{4}$	8 large.
	4	1	10 large, 1 small.
	5	$1\frac{1}{4}$	6 large, 10 small.
June 22.....	3	$\frac{3}{4}$	35 medium to large.
	4	1	40 medium to large.
	5	$1\frac{1}{4}$	28 medium to large.

At the time of the May 28 treatment many overwintered adults and first-generation larvae were present on the foliage, while on June 22, when the late application was made, many first-generation adults and a few larvae were noted on the foliage.

Many observations were made on these trees during the summer, and the following results were noted: In the early-treated plots the 4- and 5-pound dosages gave satisfactory control, whereas the 3-pound

dosage did not give so good results for the entire season as was noted with the higher dosages. In all these plots, however, there was heavy feeding at the tops of the high trees, owing to the fact that a strong wind was blowing at the time of treatment, and it was impossible to reach the tops with the spray equipment at hand. Very few larvae were noted on the sprayed portions of the trees, although at times many adults were seen on them, especially at the periods of maximum emergence from the pupae of the various generations on the many nearby heavily infested and untreated trees.

The control on the trees sprayed on June 22 was satisfactory during the entire season, although a noticeable amount of feeding had occurred previous to the time of treatment. Since these were sprayed on a calm day, the tops of the larger trees were easily reached by the spray, and were well protected. The 3-pound dosage gave good control, being practically as satisfactory as the 4- and 5-pound dosages.

In comparing the results of the early and late treatments it is apparent that the 4- and 5-pound dosages, both in the early and late applications, gave satisfactory results. The 3-pound dosage, applied early, was not so efficient as the 4- and 5-pound dosages applied at the same time, but with the late applications 3 pounds was practically as efficient as 4 or 5 pounds. It should be added, however, that the early spray residues were subjected to more than $2\frac{1}{2}$ inches of rain before the late application was made. The total rainfall during June, July, and August was 6.26 inches, only 3.8 inches of which fell after the spraying on June 22. The normal rainfall here for June, July, and August, which approximates the period in which the early spray deposit was exposed is 10 inches, whereas the normal rainfall for the approximate period to which the late dosages were exposed is between 7 and 8 inches. In either case the rainfall was much below normal.

SUMMARY

The imported willow leaf beetle (*Plagioder a versicolora* (Laich.)) is a small, robust beetle of a metallic-blue color, sometimes tinged with red or bronze. It hibernates as an adult; and, in eastern New England, issues from hibernation the latter part of April or early in May. It has three full generations and a partial fourth. These broods overlap, and the damage they do becomes considerable after the middle or latter part of June. It prefers to feed on the black willow and the golden willow, but it also feeds on the Babylon weeping willow, and the shiny willow.

This insect is controlled to a greater or less extent by the parasite *Schizonotus sieboldi* (Ratz.). Extremely cold winters are fatal to adults not well protected.

The insect can be controlled efficiently by spraying with lead arsenate at the rate of 4 pounds to 100 gallons of water, if it is applied between May 25 and June 25, in the New England States; after that period 3 pounds of lead arsenate to 100 gallons of water could be used, but considerable damage will have been already done. Fish oil should be added as an adhesive. If fish oil is not available, linseed oil can be substituted, but either should be used at the rate of 4 fluid ounces ($\frac{1}{4}$ pint) to each pound of poison in the spray tank. Care should be taken to treat the under surface of the foliage, since the greater majority of the larvae feed from beneath.

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